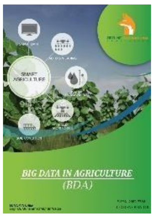
ZIBELINE INTERNATIONAL™ PUBLISHING
ISSN: 2682-7786 (Online)
CODEN: BDAIDR

Big Data in Agriculture (BDA)

DOI: http://doi.org/10.26480/bda.01.2026.37.40



CrossMark

RESEARCH ARTICLE

TRADE-OFFS IN MECHANIZED MAIZE SEED HARVESTING: EVIDENCE FROM NEPAL'S KOSHI PROVINCE

Manoj Kumar Joshi[a*], Mukti Nath Jha[a], Ravi Prasad Chaudhari[b], Shamshad Ansari[c], Shiva Kumar Jha[a], Sachin Kumar Mishra[d], Shreemat Shrestha[a]

[a] National Agricultural Engineering Research Center, Khumaltar, lalitpur
[b] Directorate of Agricultural Development, Bagmati Province, Lalitpur
[c] Directorate of Agricultural Research, Koshi Province, Tarahara, Sunsari
[d] Agriculture Implement Research Station, Birgunj, Parsa
Corresponding Author email: ma.kumarjoshi@gmail.com

ARTICLE DETAILS

Article History:

Received 10 January 2026
Revised 20 February 2026
Accepted 28 March 2026
Available online 17 April 2026

ABSTRACT

Owing to labor shortages during the peak harvesting season, mechanized harvesting of maize is often advocated in Nepal; however, its efficacy, particularly for maize seed production, is still doubtful because of the possibility of seed damage. In this study, we examined the operational efficiency of the fully mechanized maize harvesting method, i.e., a track-type combine harvester, and compared it with the traditional harvesting/threshing method and with manual harvesting followed by an electric maize sheller for seed viability at the on-station of the Directorate of Agricultural Research, Koshi Province. The variety under study was Rampur composite, which is an open-pollinated improved maize variety that is widely adopted in the Terai and inner Terai regions of Nepal. The theoretical field capacity, actual field capacity, and field efficiency were calculated to be 0.595 ha hr^{-1}, 0.393 ha hr^{-1}, and 66.05%, respectively, for the harvester. The standard lab germination test revealed that we have to compromise almost 10% germination as compared to the other two methods while using the combine harvester. Also, using a combine harvester to harvest one hectare maize adds 28.8 kg of CO_2 equivalent to the atmosphere that directly contributes to climate change. This study quantified evidence on performance of combine harvester, trade-offs in seed viability, and added greenhouse gas emission to the environment while using mechanization in harvesting of maize seed in Nepal.

KEYWORDS

combine harvester, maize harvesting, trade-offs, mechanization, viability

1. INTRODUCTION

Maize (*Zea mays* L.) is reported to be a major cereal crop worldwide due to its versatility in food, feed, and industrial applications and remains central to agricultural production systems in Asia (Dass et al., 2025; Timsina et al., 2010). Maize is a leading cereal of the world in terms of production and is claimed to be the most widely grown and traded crop because of its growing demand, technological advances, and increased production (Erenstein et al., 2022). Furthermore, it is the second most widely cultivated crop in Nepal, after rice, where it is the first cereal crop for hilly communities for food and a major feed source for the sharply expanding livestock sector in the Terai, contributing to both food and feed security amidst climate change challenges (Awika, 2011; Kc et al., 2015). Despite its importance, maize production and quality seed availability in Nepal are constrained by limited access to high-quality seeds, low seed replacement rates, and inefficiencies in production and seed systems(Gairhe et al., 2021a).

Furthermore, a group researcher reported that only a small proportion of maize area in Nepal is planted with improved seed from formal sources, and that formal seed supply systems struggle to meet national demand (Gairhe et al., 2021). In 2022/23, Nepal imported maize and maize products worth approximately USD 6.79 million, of which seed alone accounted for approximately USD 84,000, to meet demand across various sectors (Government of Nepal, 2023). To reduce maize imports, improving maize seed production and quality is therefore critical to enhancing productivity and supporting resilient cropping systems in the country (Gairhe et al., 2021b).

Agricultural mechanization has been increasingly recognized as a strategy to address labor shortages, reduce drudgery, and improve the timeliness and efficiency of field operations in Nepalese agriculture (Gauchan and Shrestha, 2017). Labor-intensive operations such as harvesting are particularly affected by rural out-migration and rising labor costs, making mechanized solutions desirable for smallholders practicing cereal production. Among mechanized options, combine harvesters represent advanced technology that integrates reaping, threshing, and cleaning processes into a single operation, reducing labor requirements and field losses while improving operational efficiency. While combine harvesting is widely used in commercial maize grain production globally, its application in seed-grade maize production remains underexplored and feed grade maize harvesting is limited to demonstration levels only in Nepal, where small field sizes and farm conditions differ from those of large mechanized system. Higher than 50-53% Nepalese farmers has less than 0.5 hectare land holding (Gc and Hall, 2020).

High seed quality, particularly germination and vigour, is essential for successful crop establishment and yield. Maize seeds are highly susceptible to mechanical damage during harvesting and post-harvest handling, especially when machine settings are not optimized or when crop moisture conditions are unfavorable. Mechanical impacts and abrasion during combine harvesting can impair embryo integrity and reduce physiological seed quality even without visible external damage, posing a significant risk to seed producers. Although studies have evaluated general mechanization and harvesting technologies, empirical research that jointly assesses the operational performance metrics and seed quality outcomes of combine harvesting in maize seed systems in

Quick Response Code	Access this article online	
	Website: www.bigdatainagriculture.com.my	**DOI:** 10.26480/bda.01.2026.37.40

Cite The Article: Manoj Kumar Joshi, Mukti Nath Jha, Ravi Prasad Chaudhari, Shamshad Ansari, Shiva Kumar Jha, Sachin Kumar Mishra, Shreemat Shrestha (2026). Trade-Offs in Mechanized Maize Seed Harvesting: Evidence from Nepal's Koshi Province:. *Big Data in Agriculture (BDA)*, 8, (1): 37-40.

Nepal is limited. This lack of integrated evidence constrains evidence-based recommendations for mechanization strategies that align efficiency gains with seed quality preservation in formal seed production systems. To address this gap, the present study evaluated the performance efficiency of a crawler-type combine harvester and assessed the associated trade-offs in terms of seed viability in maize seed production plots of Directorate of Agricultural Research, Koshi Province, Nepal. The study specifically examines field capacity, field efficiency, grain loss, fuel consumption, and seed germination of combine-harvested maize compared with manually and mechanically threshed seeds. The findings provide practical insights for agricultural engineers/researchers, seed producers, and policymakers seeking to optimize mechanized harvesting approaches that balance operational efficiency with seed quality preservation in Nepal and similar agro-ecological contexts.

2. Materials And Method

2.1 Study Area and Experimental Setup

The field experiment and germination test were conducted during the Maize season (December-May) of 2023/2024 at the Directorate of Agricultural Research, Koshi Province, Tarahara, Sunsari district, Nepal, which is situated at an altitude of approximately 120 m above sea level. The site falls within the Terai agroecological zone and experiences a subtropical monsoon climate, with an average annual rainfall of approximately 1945 mm, 36% of which occurs in December-May, and the mean temperature ranges from 19-31 °C during the cropping season. The soil at the experimental site is clay loam, with a pH of 6.5-7, and moderate fertility levels.

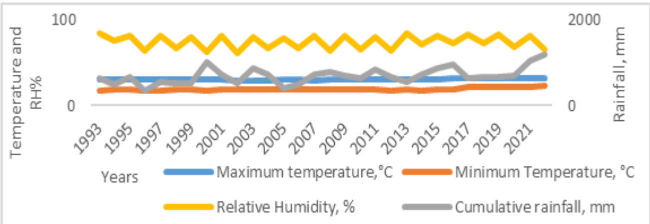


Figure 1: Climatic details of the study location during the study season

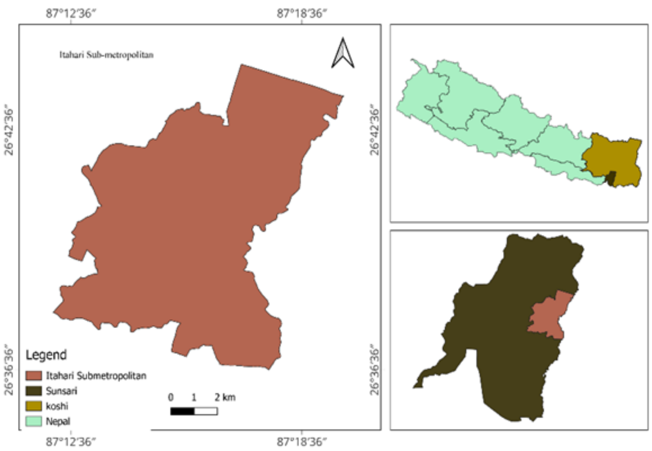


Figure 2: Study area map

2.2 Harvesting Equipment and Operation

Table 1: Technical specifications of the track type self-propelled combine harvester used in the study

Specification	Details
Type	Track Type Combine Harvester
Engine Power	100 HP
Threshing System	Axial flow type
Cutter Bar Width	2.2 meters
Track Width	500 mm
Fuel Type	Diesel
Fuel Tank Capacity	100 liters
Grain Tank Capacity	1.5 tons

Table 1 (Cont): Technical specifications of the track type self-propelled combine harvester used in the study

Specification	Details
Ground Clearance	~300–400 mm
Dimensions (L×W×H)	~5500 × 2500 × 3000 mm
Special Features	Suitable for soft and wet fields; low ground pressure due to tracks

A crawler-type 100 HP multi crop self-propelled combine harvester with a maize harvesting attachment was used for the study. Combine harvesters are used to integrate reaping, threshing, and cleaning processes and are widely used in paddy and wheat harvesting. The machine was operated at recommended speeds. Harvesting was performed after 10 days of physiological maturity, with a grain moisture content of approximately 20–25%.

2.3 Harvesting and post-harvest processing

For the treatments under study for germination tests, immediately after harvesting, the maize ears were collected and subjected to sun drying to reduce the moisture content. Threshing was performed via two different postharvest methods to assess the impact on seed quality, particularly germination percentage, and the results were compared with those of combine harvester harvested seeds.

Treatments under consideration for germination tests

T1: Manual harvesting + Manual threshing (Traditional method)

T2: Manual harvesting + Electric maize sheller (Semi-mechanized method)

T3: Crawler type self-propelled combine harvester (Fully-mechanized method)

These treatments were replicated three times, and samples were randomly collected for germination tests in the laboratory.

2.4 Field Performance Evaluation

The performance parameters of the combine harvester were assessed during field operation:

The theoretical field capacity (TFC) was calculated using the formula:

$$TFC\left(\frac{ha}{hr}\right) = \frac{Width(m) * Speed\ of\ operation(\frac{km}{hr})}{10} \quad (1)$$

Actual Field Capacity (AFC) was measured by timing the area harvested over multiple field passes.

The field efficiency (%) was derived as follows:

$$Field\ Efficiency = \frac{AFC}{TFC} * 100 \quad (2)$$

Grain Loss Measurement: After harvesting, random plots within the harvested area were sampled to collect and weigh unthreshed cobs and loose grains. The total grain loss was calculated in kilograms per hectare.

2.5 Fuel Consumption

The fuel consumption of the harvester was recorded via the full tank method. The average consumption rate was computed in litres per hour during full operation.

2.6 Germination Test

To assess the impact of the harvesting and threshing methods on seed quality, standard germination tests were performed as per standard germination test procedures (using moist rolled paper towels, keeping them at 25°C (77°F) for 7 days, checking them daily for moisture, counting normal seedlings to calculate percentages, and assessing seed potential under favorable warmth). For each treatment, randomly sampled seeds were tested in a controlled environment with three replications. The data were subjected to analysis of variance (ANOVA), and the means were separated using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

3. Results And Discussion

3.1 Field Performance of the Combine Harvester

The crawler-type combine harvester was evaluated under typical field conditions in the maize seed production block. The actual field capacity (AFC) was measured at 0.393 hectares per hour, whereas the theoretical field capacity (TFC) was 0.595 hectares per hour, resulting in a field efficiency of 66.05%. The relatively high efficiency indicates good operator control and well-prepared field conditions, although some losses in efficiency are attributed to turning, small plot sizes.

Photo 1: Sample photographs of the field operation of the crawler type combine harvester and laboratory germination of maize

The fuel consumption of the combine harvester was recorded to be 7.8 liters per hour, which is within the typical range for 100 HP machines operating under medium to heavy crop loads. This level of consumption suggests that the crawler-type harvester is a viable option for maize fields, particularly in regions with soft soils, where wheeled harvesters may be less effective.

3.2 Grain losses during harvesting

Grain loss was assessed by collecting threshed grains and unthreshed cobs left in the field after harvesting. The total grain loss was minimal, measured at 1.04 kg/ha, indicating excellent threshing and cleaning efficiency of the machine. This value falls well below the acceptable grain loss threshold of 3% for commercial harvesting systems (FAO, 2016). Low loss levels also reflect proper machine adjustment and crop maturity at harvest.

3.3 Germination test

Seed germination is a critical parameter when evaluating harvesting methods for seed production. A standard laboratory germination test was performed to assess the physiological integrity of seeds from different treatments. The results are summarized in Table 2.

Table 2: Germination percentage of maize seeds harvested via different methods

Treatments	**Germination**
T1: Traditional	98.667[a]
T2: Semi-mechanized	98[a]
T3: Fully-mechanized	88.667[b]
CV%	3.68
P value	0.0222

Note: CI of 95%

Analysis of variance revealed a significant difference in the germination rate (P = 0.0222) between the treatments. Compared with those processed manually (T1) or using a maize thresher (T2), the seeds harvested via the combine harvester (T3) presented significantly lower germination rates (88.67%), with germination rates of approximately 98%.

This result may be attributed to mechanical damage caused by the threshing drum inside the combine, which seems to have been designed for grain recovery rather than seed preservation. Mechanical stress during combine harvesting can crack seed coats and damage embryos, adversely affecting viability. Although the combine harvester is efficient in terms of operational performance and grain recovery, these findings raise concerns about its use for seed-grade maize, especially when high germination standards are needed.

This reduction in germination is significant while considered for millions of hectares of maize production and will cost major volume of economic loss. But fully mechanized system can be used if the maize is to be used for livestock feed and food.

3.4 Economic and environmental implications

Table 3: Cost, labor, time saving and GHG emission equivalent comparison for different treatments

Treatment	Cost saving	Labor saving	Time saving	GHG emissions (CO_2-eq/ha)
	vs manual	vs manual	vs manual	
T1: Fully Manual	0%	0	0%	~0 kg
				(human energy only)
T2: Semi Mechanized	25–30%	60–65%	30–35%	~0 kg (hydroelectricity is operation neutral)
T3: Fully Mechanized	35–40%	80–85%	85–90%	28.8 kg CO_2-eq/ha

(Note: Custom hiring rate of combine harvester was considered to be NRs 9000/ha)

We observed that in manual maize harvesting systems, harvesting and delivering to drying and threshing floor alone requires high labor inputs 22 man-hours per hectare and represents a significant cost component in overall production, which was also reported (FAO, 1994). Mechanized threshing alone reduces 60-65% of labor as compared to the fully manual system, which is Nepal's traditional method of maize shelling. Furthermore, the T2 saves 39-35% time as compared to the T1, and it is an operation-neutral operation in terms of greenhouse gas (GHG) emission. Whereas T3 is the most efficient operation in terms of cost, labor, and time saving. But it adds 28.8 kg CO_2-eq/ha GHG to the atmosphere for each hectare of maize harvested by this method. In the last method.

3.5 Environmental trade-offs of using combine harvesters

There is an environmental trade-off in using a combine harvester to harvest maize: approximately 28.8kg of carbon dioxide equivalent is produced when harvesting one hectare of maize, which results from burning 11.4 L/ha of diesel fuel, as calculated by the (US EPA, 2015). This means if all of the maize in the plain region of Nepal is harvested using combines, about 4638.015 tons of CO_2 equivalent greenhouse gas will be released to the atmosphere, while the other two methods are carbon neutral operations. Not only that but also, compaction caused by using farm machineries especially heavy equipment such as combine harvester compacts soil (Nasir et al., 2021). Soil compaction influences the physical characteristics of soil, specifically by elevating bulk density and soil strength, simultaneously reducing pore space and hydraulic functions, thereby blocking root penetration. Consequently, the transport and accessibility of water and nutrients to crops are restricted, which negatively impacts root development, plant growth, and overall crop yield. In extreme circumstances, especially those involving recurrent heavy machinery traffic, soil compaction can result in significant yield reductions, potentially exceeding 50% (Liu et al., 2022; Shaheb et al., 2021).

4. Conclusion

This study assessed the performance of a crawler-type combine harvester and its impact on seed quality in maize seed production systems and

Cite The Article: Manoj Kumar Joshi, Mukti Nath Jha, Ravi Prasad Chaudhari, Shamshad Ansari, Shiva Kumar Jha, Sachin Kumar Mishra, Shreemat Shr estha (2026). Trade-Offs in Mechanized Maize Seed Harvesting: Evidence from Nepal's Koshi Province: . *Big Data in Agriculture (BDA)*, 8, (1): 37-40.

compared it with the semi mechanized and traditional method of maize harvesting and threshing in eastern Nepal. The combine harvester showed satisfactory operational performance, with an actual field capacity of 0.393 ha hr^{1}, field efficiency of 66.05%, negligible grain loss (1.04 kg ha^{1}), and fuel consumption (7.8 L hr^{1}), demonstrating its suitability for timely and efficient maize harvesting. However, seed quality analysis revealed a significantly lower germination percentage in combine-harvested seeds (88.67%) than in manually and mechanically threshed seeds (>98%). These findings indicate that mechanical damage during combine harvesting can adversely affect seed viability. While combine harvesting offers clear advantages in reducing labor dependency and improving efficiency, its use in maize seed production requires optimization of machine settings and seed-specific harvesting protocols. Targeted technical adjustments are essential to balance mechanization benefits with the preservation of seed quality.

To ensure the integration of combine harvesting in maize maize/seed systems, the following recommended:

- The combine harvester settings (e.g., drum speed, and concave clearance) should be optimized and maize maturity should be optimized for maize seeds.
- Subsidy should be given on operation cost as well to assure benefits of end users of combine harvesters and also to increase adoption of the technology.
- Further research should be conducted on maize varieties with stronger seed coats or improved resistance to mechanical stress, and optimum harvesting stage of maize seed.
- Training programs should be developed for operators focusing on seed-friendly harvesting practices.

References

Agricultural engineering in development—Table of Contents. (n.d.). Retrieved January 3, 2026, from https://www.fao.org/4/t0522e/T0522E00.htm#Contents

Annual Foreign Trade Statistics Book 2079-80_570y4ss.pdf. (n.d.). Retrieved January 3, 2026, from https://giwmscdnone.gov.np/media/files/Annual%20Foreign%20Trade%20%20Statistics%20Book%202079-80_570y4ss.pdf

Awika, J. M. 2011. Major Cereal Grains Production and Use around the World. In Advances in Cereal Science: Implications to Food Processing and Health Promotion (1089, pp. 1–13). American Chemical Society.

Dass, S., Gangadhar Karjagi, C., Singh, M., and Singh, D. K. 2025. Maize: An Introduction. In S. Dass, C. Gangadhar Karjagi, D. K. Singh, & M. Singh (Eds.), Maize Breeding: Production, Protection and Management for Optimization of Natural Resources (pp. 1–32). Springer Nature. https://doi.org/10.1007/978-981-95-1418-2_1

Erenstein, O., Jaleta, M., Sonder, K., Mottaleb, K., and Prasanna, B. M. 2022. Global maize production, consumption and trade: Trends and R&D implications. Food Security, 14(5), 1295–1319. https://doi.org/10.1007/s12571-022-01288-7

Gairhe, S., Timsina, K.P., Ghimire, Y.N., Lamichhane, J., Subedi, S., and Shrestha, J. 2021a. Production and distribution system of maize seed in Nepal. Heliyon, 7(4). https://doi.org/10.1016/j.heliyon.2021.e06775

Gairhe, S., Timsina, K.P., Ghimire, Y.N., Lamichhane, J., Subedi, S., and Shrestha, J., 2021b. Production and distribution system of maize seed in Nepal. Heliyon, 7(4), e06775. https://doi.org/10.1016/j.heliyon.2021.e06775

Gauchan, D., and Shrestha, S., 2017. Agricultural and rural mechanisation in Nepal: Status, issues and options for future. Institute for Inclusive Finance and Development (InM). https://hdl.handle.net/10568/87968

Gc, R.K., and Hall, R.P. 2020. The Commercialization of Smallholder Farming—A Case Study from the Rural Western Middle Hills of Nepal. Agriculture, 10 (5). https://doi.org/10.3390/agriculture10050143

Kc, G., Karki, T.B., Shrestha, J., and Achhami, B.B., 2015. Status and prospects of maize research in Nepal. Journal of Maize Research and Development, 1(1), 1–9. https://doi.org/10.3126/jmrd.v1i1.14239

Liu, H., Colombi, T., Jäck, O., Keller, T., and Weih, M. 2022. Effects of soil compaction on grain yield of wheat depend on weather conditions. Science of The Total Environment, 807, 150763.

Shaheb, M.R., Venkatesh, R., Shearer, S. 2021. A Review on the Effect of Soil Compaction and its Management for Sustainable Crop Production. Journal of Biosystems Engineering, 46. https://doi.org/10.1007/s42853-021-00117-7

Nasir, R., Mat Su, A.S., Yahya, A., Nawi, N., and Wagiman, N. 2021. Soil Compaction Effects of Large and Mini Combine Harvesters in a Paddy Cultivation Area in MADA. Ama, Agricultural Mechanization in Asia, Africa & Latin America, 52, 3917–3939.

Timsina, J., Jat, M. L., Majumdar, K. 2010. Rice-maize systems of South Asia: Current status, future prospects and research priorities for nutrient management. Plant and Soil, 335(1), 65–82. https://doi.org/10.1007/s11104-010-0418-y

US EPA, O. 2015. Greenhouse Gas Equivalencies Calculator [Data and Tools]. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator